

# DOE Transmission Reliability Program Peer Review

## *WAMS Outreach Projects in FY03*

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Prepared for the Transmission Reliability Program – 2004 Program Peer  
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# Organization of WAMS Outreach Presentations

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- **Overview of WAMS Outreach activities**
- **WAMS Outreach Projects:**
  - **Controller Certification Tools**
  - **WAMS Outreach–Sharing Knowledge & Technology**
    - Assistance in WAMS startup operations
    - Application of WAMS technologies  
(system tests, disturbance analysis)
    - Validation of system dynamic performance
    - PMU evaluation & standards
  - **WECC Model Validation**

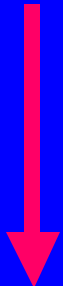


# ***Challenge: Transmission Reliability During the Transition to Open Markets in Electrical Energy***

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## **Federal Utilities**

- "Lead by example"
- Share special technologies & expertise with other utilities
- Support the public good



## **National Laboratories**

- Consolidate and share special knowledge and expertise relating to electrical systems
- Consolidate, adapt, and share Federally owned technologies for electrical system use
- Track, assess, and report emerging needs in reliability assurance



## **Strategic Objectives in the WAMS Effort: *Reinforcing the Grid Management Process***

- **Determine information needs of the new power system**
  - Control & protection
  - Planning & operations
  - Reliability management & workflow coordination
- **Facilitate development of information resources**
  - Value based development & deployment of technology
  - Demonstration & refinement of investment value
  - Maintaining necessary collaborations among stakeholders
- **Promote & support sound engineering practice**
  - Effective but prudent use of automatic control
  - Comprehensive methods for planning & operations
  - Functionalities & infrastructure for reliability management



## DOE/CERTS WAMS Outreach FY2003: Core Projects and External Linkages

### Primary Elements:

- *Dissemination of Knowledge and Technology for Measurement-Based Reliability Management*
- *Assist in validation of System Dynamic Performance & Modeling*
- *Certification tools for large scale damping controllers*

### Utility Linkages:

- **Federal Utilities:** BPA, Western, USBR
- **WSCC utilities & technical bodies:**
  - *Disturbance Monitoring Work Group (DMWG)*
  - *Modeling & Validation Work Group (M&VWG)*
- **Eastern Interconnection utilities & technical bodies:**  
*NERC, ISOs, WAMS facility owners (AEP, Ameren, Entergy, TVA, etc)*

Other Linkages: Vendors, professional groups, universities



## DOE/CERTS WAMS Outreach FY2003: Related CERTS Projects & Activities

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- *Roadmap for Real-Time Control Concepts*
- *Framework for Real-Time Grid Data Archive and Analysis*
- *Control Schemes for Real-Time Control*
- *Eastern Interconnection Phasor Demonstration Project (EIPP)*
- *Analysis support for U.S.-Canada Blackout of August 14, 2003 [A,B]*

[A] "Performance of 'WAMS East' in Providing Dynamic Information for the North East Blackout of August 14, 2003", J. F. Hauer, Navin Bhatt, Kirit Shah, and Sharma Kolluri. Accepted as an invited paper for IEEE/PES Panel on Major Grid Blackouts of 2003 in North America and Europe, IEEE PES General Meeting, Denver, CO, June 6-12, 2004.

[B] "Data Management Issues Associated with the August 14, 2003 Blackout Investigation", J. E. Dagle. Accepted as an invited paper for IEEE/PES Panel on Major Grid Blackouts of 2003 in North America and Europe, IEEE PES General Meeting, Denver, CO, June 6-12, 2004.



# WAMS Technology Targets for "WAMS East"

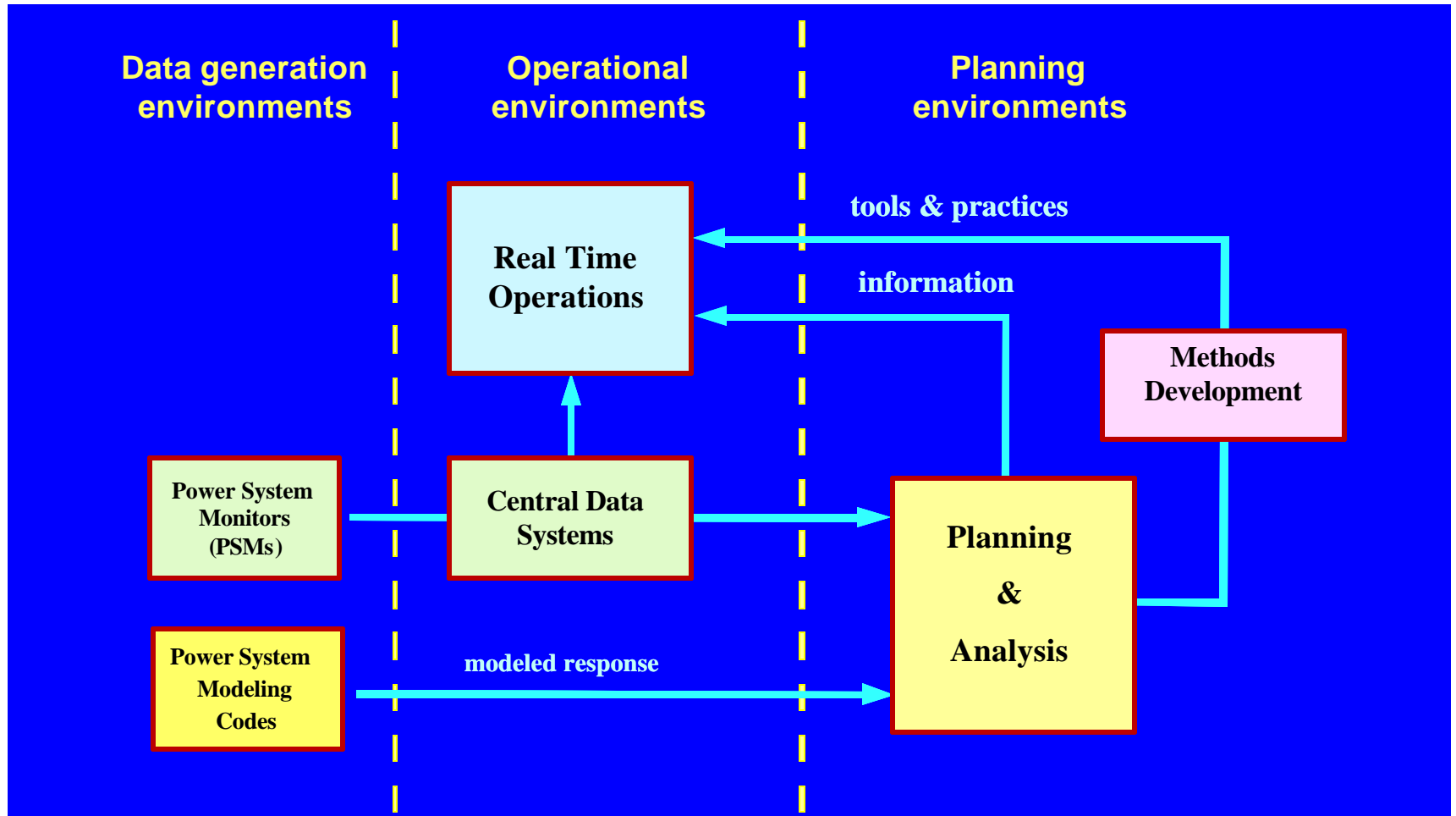
- **Extend IEEE SynchroPhasor standard<sup>1</sup> to include**
  - major control systems, especial HVDC and FACTS
  - generation projects that are critical to power system performance
  - critically placed relays
  - high level SCADA
- **Adapt WAMS technology and operating experience to needs of the eastern interconnection:**
  - lower data rates for flowgate monitoring
  - technology deployment strategies adjusted to information needs and legacy equipment in the eastern interconnection

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<sup>1</sup> "IEEE Standard for Synchrophasors for Power Systems," K. E. Martin et al., IEEE Trans. Power Delivery, Vol. 13 Issue 1 , pp. 73-77, Jan. 1998.



# *Good Information: The key to managing complexity*





# Validation of System Performance & Modeling

## Measurement process:

**Determine actual system performance from tests or disturbances. *This is an ongoing effort.***

## Calibration process:

**Compare model against system. May require a wide range of time/frequency tools plus expertise in the mathematics of dynamic systems.**

**Adjust model to improve comparison. Presently an art that requires expert knowledge of planning practices. (Some automation may be feasible. )**

## Uncertainty Modeling:

**Over time, determine & characterize errors in predictive modeling. *This too is an ongoing effort.***



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**Wide Area Control:**  
***A definitive sufficiency  
test of grid management  
resources***



# DOE Transmission Reliability Program Peer Review

## *WAMS Outreach Project: Controller Certification Tools*

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# Project: Controller Certification Tools

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## Objectives:

1. Extend phasor network technology to incorporate controller information.
2. Extend probing signal technology for non-intrusive testing of controller effects across the power system.
3. Develop the Pacific HVDC Intertie as a general testbed for concepts and methodology associated with large scale FACTS control.
4. Report findings for inclusion in WECC/NERC/IEEE recommended practices for the design, certification, and operation of major control systems.



# Project: Controller Certification Tools

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## Milestones: (established prior to August 14 Blackout)

1. Continued refinement of Phase #1 instrumentation for low level probing (in progress)
2. BPA/PNNL report on mid-level tests of summer 2003 (October 2003)
3. Low-level tests with random noise (October-December 2003)
4. Draft report on test objectives, procedures, and supporting technologies (January 2004)



# Project: Controller Certification Tools

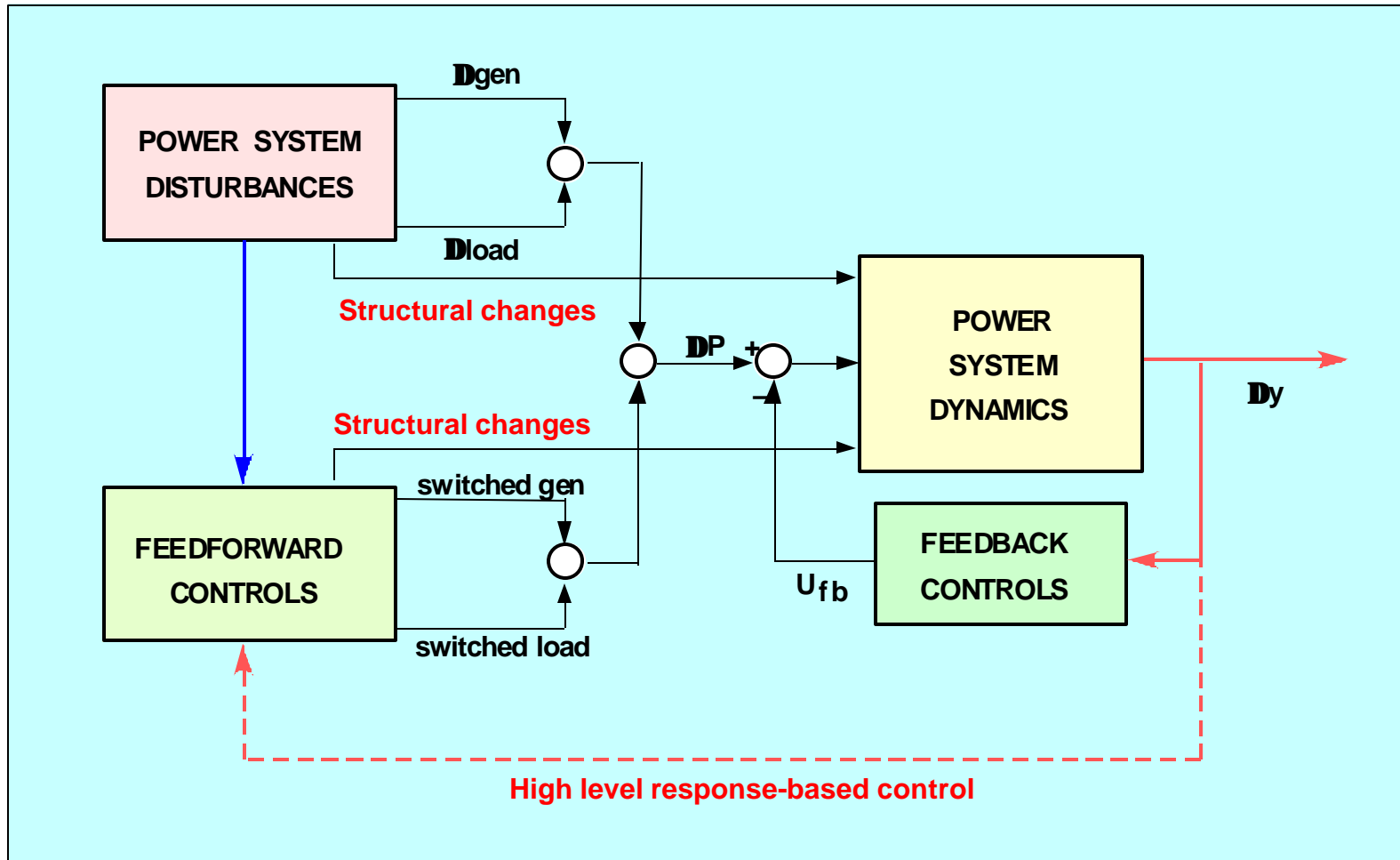
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## Progress in FY03:

1. Extensive mid-level tests have been performed during summer 2003, to assess and track system damping.
2. Results are under review as a guide to pending low-level tests, which are more general but more demanding.
3. High speed analog monitors have been enhanced for this application, and extended PMU technologies are under development to replace them.
4. An extended synchrophasor standard to support this is nearly final.
5. A great deal of analytical work has been performed but not formally reported.



# General Structure of Power System Disturbance Controls



## WAMS & FACTS: A *Perspective on Robustness*

- Functional reliability for control systems is far more complex than for new construction.
- Good design is important, but good operating practice is critical.
- Operational robustness for large scale control requires
  - *design and certification procedures* based upon directly measured system dynamics
  - *assured resources* for the prompt detection, analysis, and correction of anomalous controller effects





## **FACTS: *The Key is Infrastructure!***

***Wide area control requires  
wide area information — at all  
stages of the engineering  
process.***

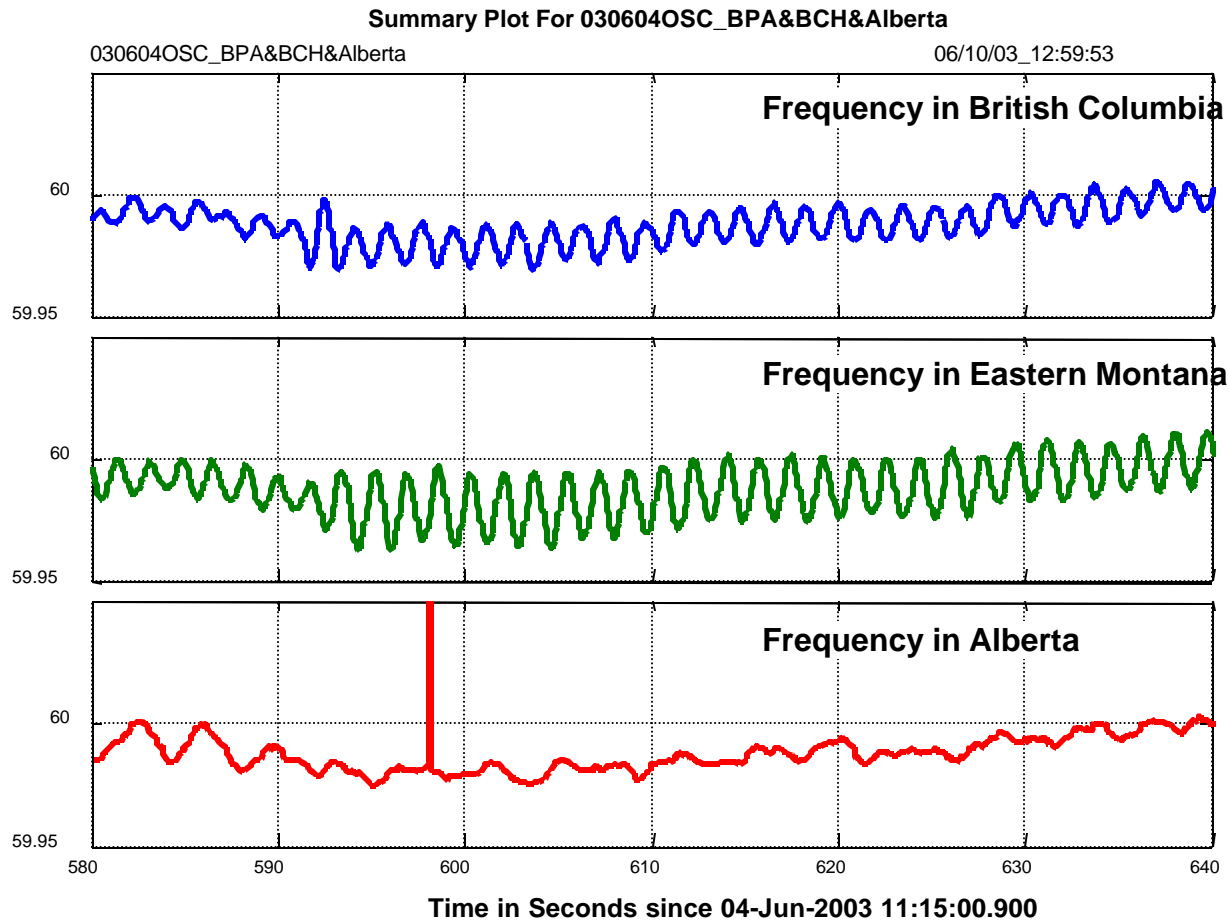


## Real-Time Applications for Phase Angle Measurements

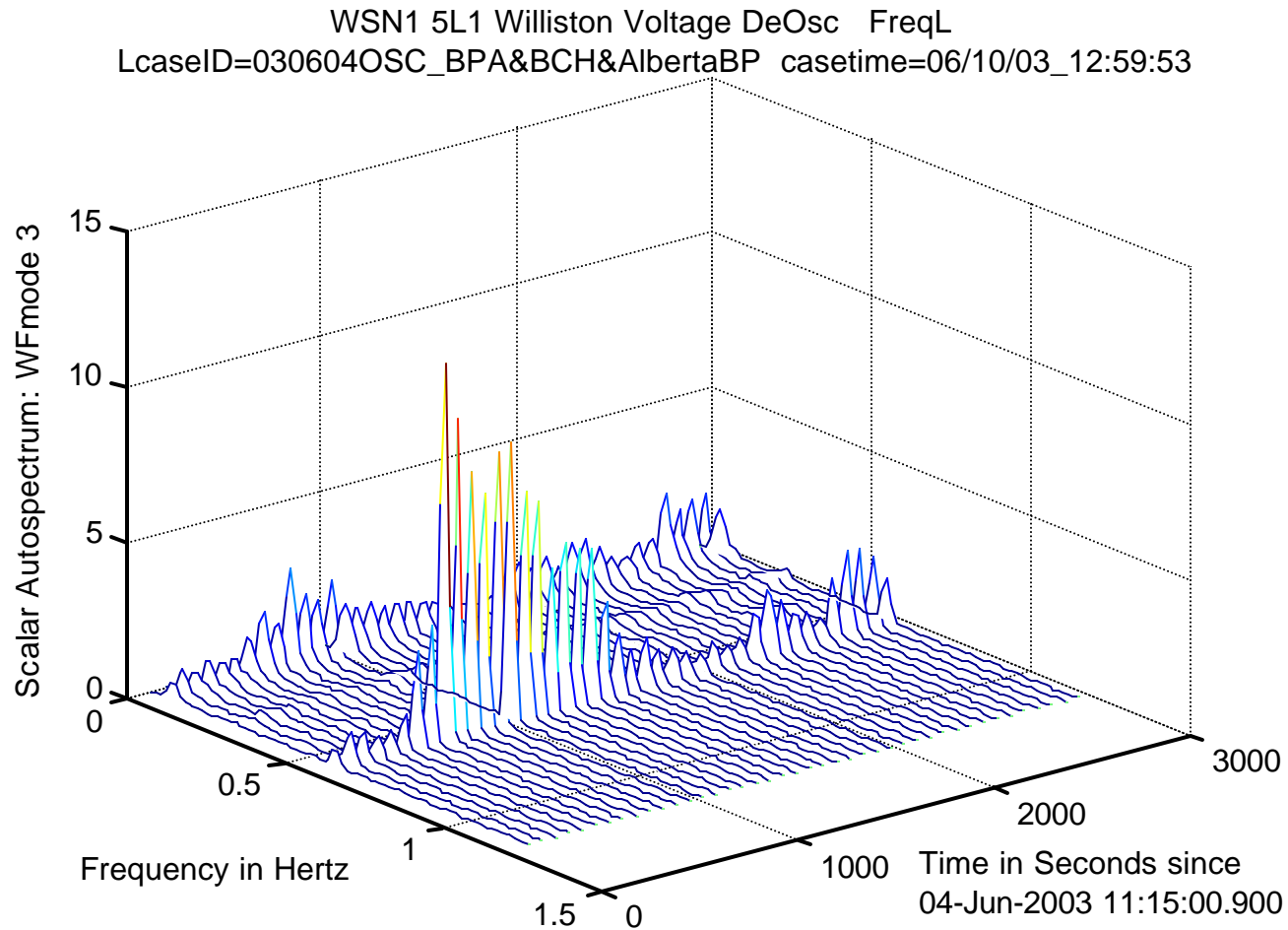
- *Basis for high quality bus frequency signals*
- Validation of system dynamic performance
- Angle-assisted state estimation
- System restoration
- Operator alerts for high-stress operating conditions
- Arming of special stability controls
- Supervision of fast stability controls
- Real-time powerflow control (e.g., phase shifters, slow TCSC)
- Modulation inputs for “bang-bang” stability controls (e.g., phase-plane controllers)
- Modulation inputs to other controller types? *PERHAPS!*



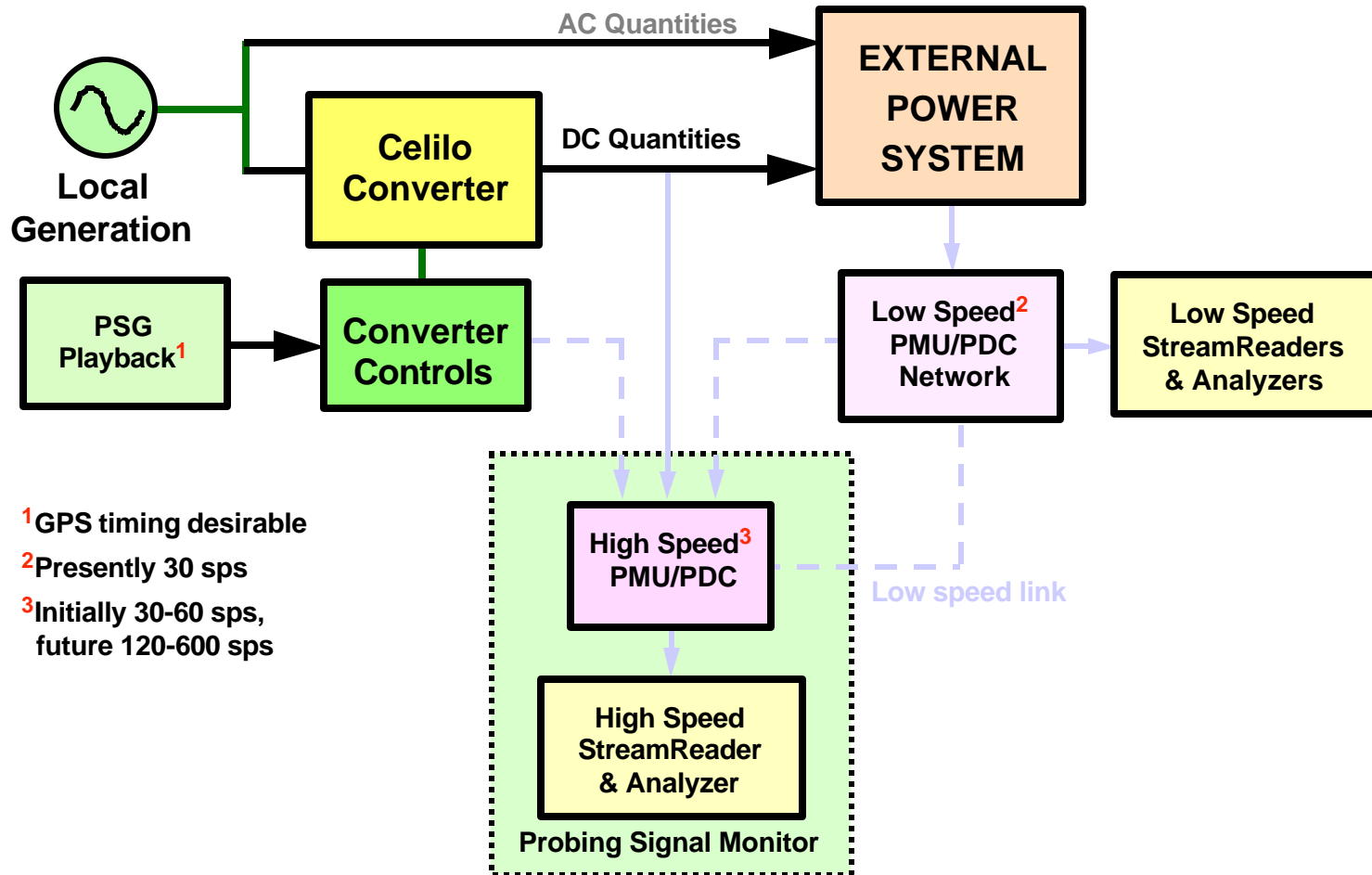
# Startup Signature for 0.584 Hz Oscillations on June 4, 2003



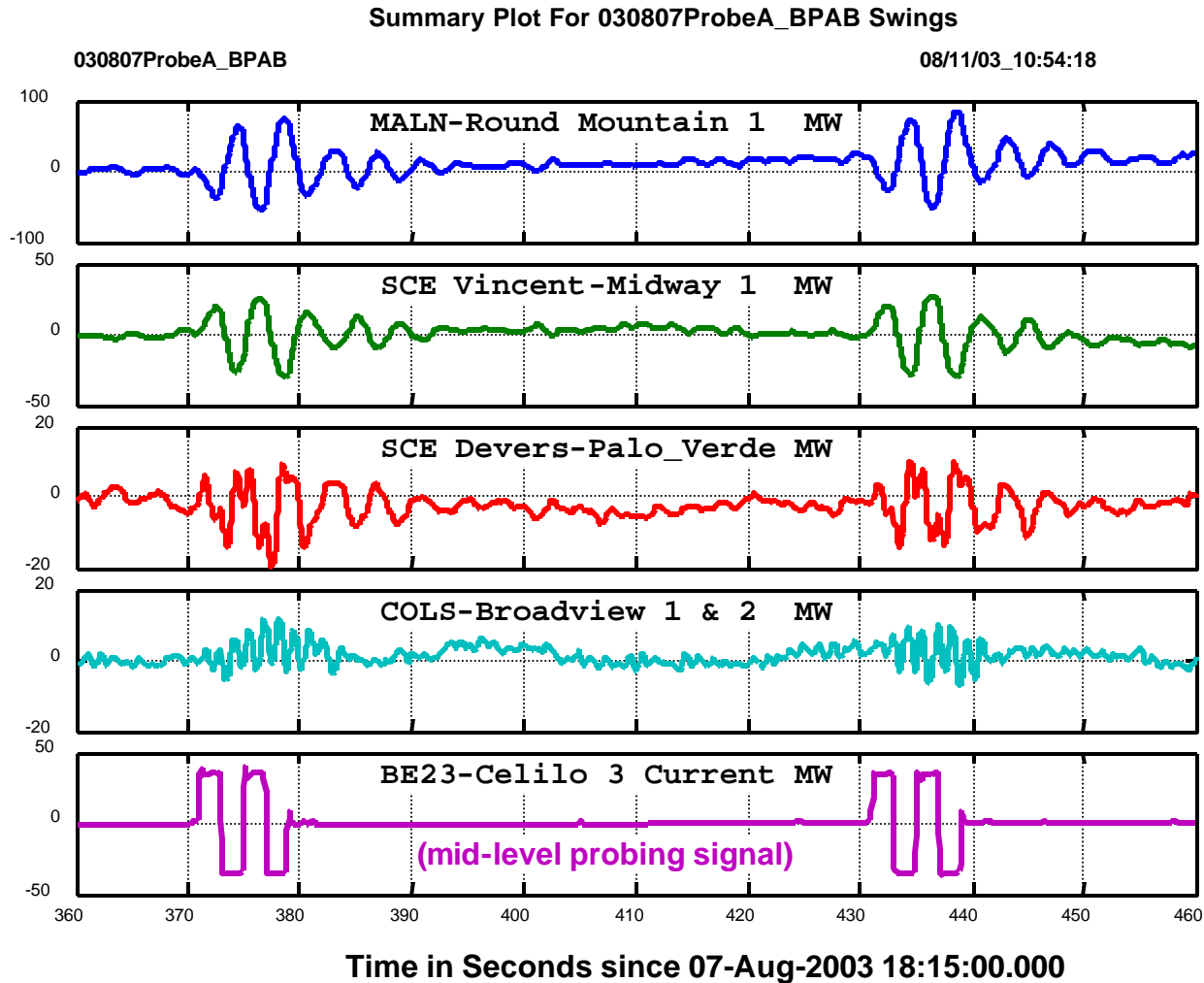
# Spectrum Waterfall plot for NW Oscillations on June 4, 2003



# Equipment for AC/DC Monitoring & Controller Certification Tests



## Key response signals for probe insertions on August 7, 2003



*The Western  
Power System:  
A challenge in  
dynamic complexity*

